Effects of Commercial Fishing on Eelgrass in New England: Characterization of Impacts and Measurements of Regrowth

Results of High Altitude Photography

Report to USGS Eastern Regional Office - State Partnership Project

Maine Department of Marine Resources Project Report
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Introduction

As part of a multi-agency USGS State Partnership Program funded study of eelgrass re-growth in Maquoit Bay, Brunswick, Maine, Maine Department of Marine Resources (MDMR) documented small (1:12,000) and medium (1:2,400) scale distribution of eelgrass throughout the bay. This work was initiated in response to reports of the destruction of eelgrass beds by commercial mussel harvesting activities in the bay. Several reports and observations were made in 1998 and 1999 of a mussel dragger or draggers harvesting in Maquoit Bay where there were dense eelgrass beds. These reports came to the attention of a USGS biologist, Hilary Neckles with the Patuxent Wildlife Research Center stationed in Augusta, Maine. Coincidentally, in 1999, MDMR had contracted for 1:2,4000 scale color aerial photography of the upper portion of Casco Bay to look at changes in eelgrass distribution for the time period since original mapping work, 1993, and to support juvenile fish habitat work being done in the area.

Eelgrass forms the basis of an important habitat along the Maine coast. Though it has not been studied as intensively north of Cape Cod as locations to the south, there is a fair amount known about distribution and biology of eelgrass in the region. As in other locations, eelgrass can form dense meadows in shallow subtidal and to a lesser extent intertidal locations. It serves many of the same functions as eelgrass beds elsewhere in that it is a dominant primary producer, provides habitat for many organisms, and serves to stabilize near shore sediments.

Maquoit Bay has offered an excellent opportunity to study re-growth of eelgrass after meadows had been disrupted by a number of commercial harvesting methods. It was apparent from aerial photography taken in 1999 (Figure1.) and from field observations that in recent years fairly extensive portions of Maquoit Bay had been impacted by mussel harvesting activities. It was also clear that eelgrass beds in Maquoit Bay had expanded since they were mapped in 1993 and that there was evidence of marine worm and soft clam harvesting activities that continued to take place in eelgrass (Figure 2.). In addition, other uses of the Bay such as boating may have had impacts on eelgrass beds.

Figure 1. Limits of study area, approximate low water and visible impacts from dragging. Maquoit Bay, 1999.

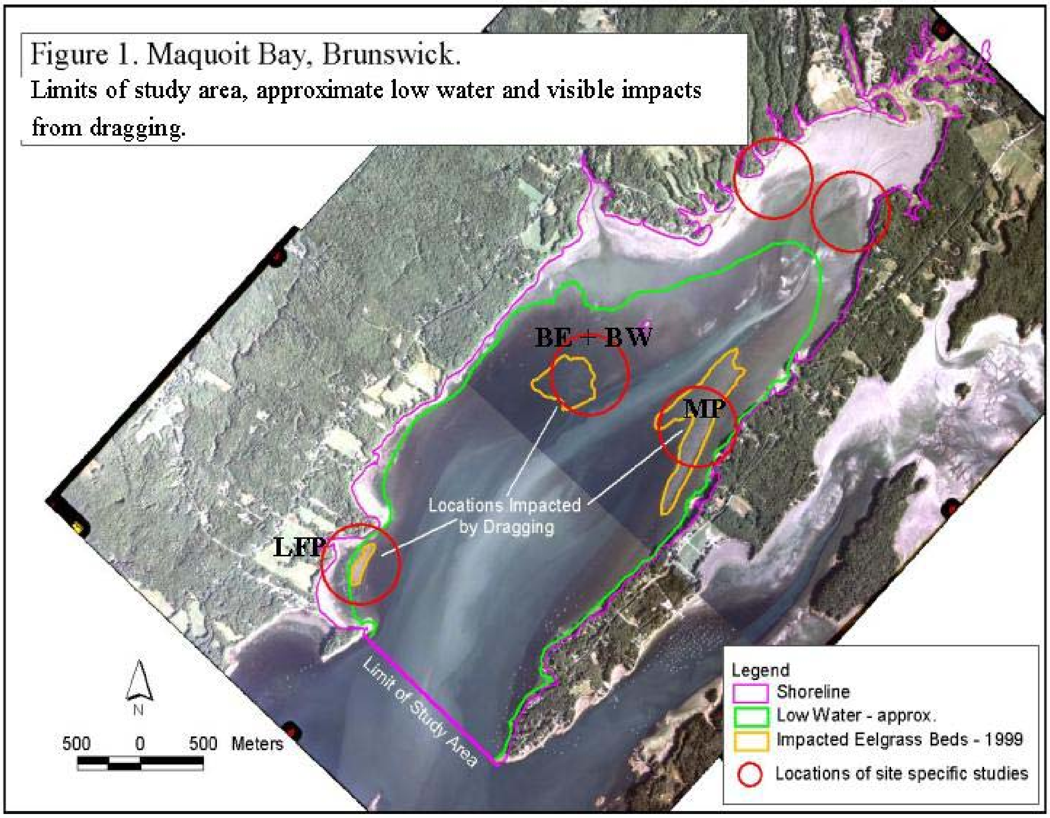
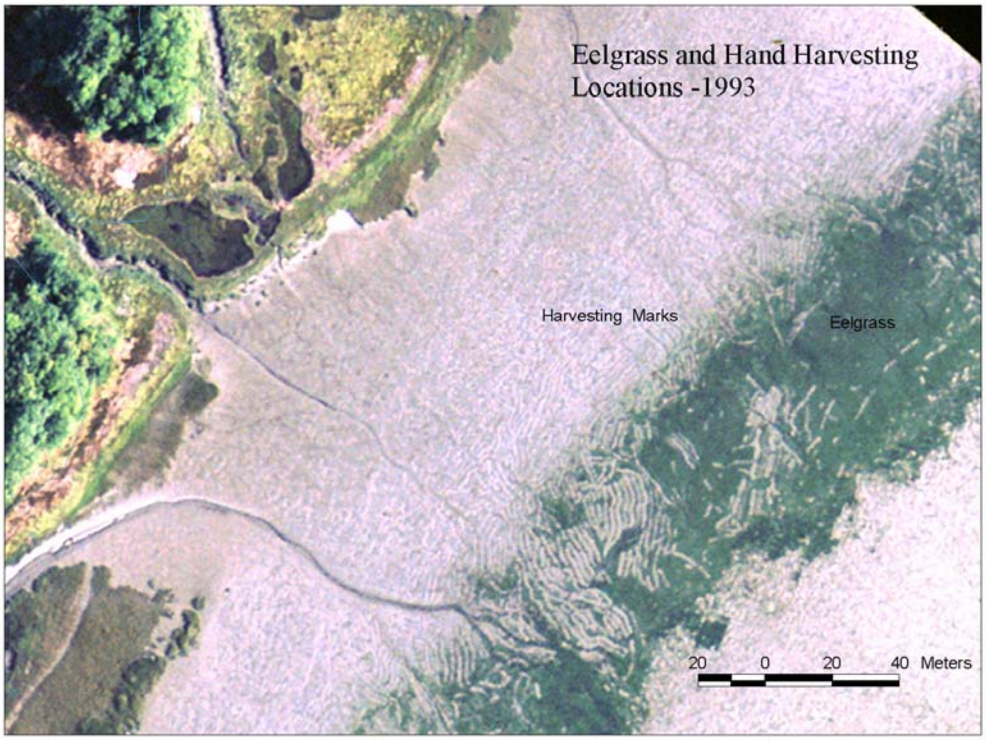


Figure 2. Example of hand harvesting impacts. Maquoit Bay, 1993.



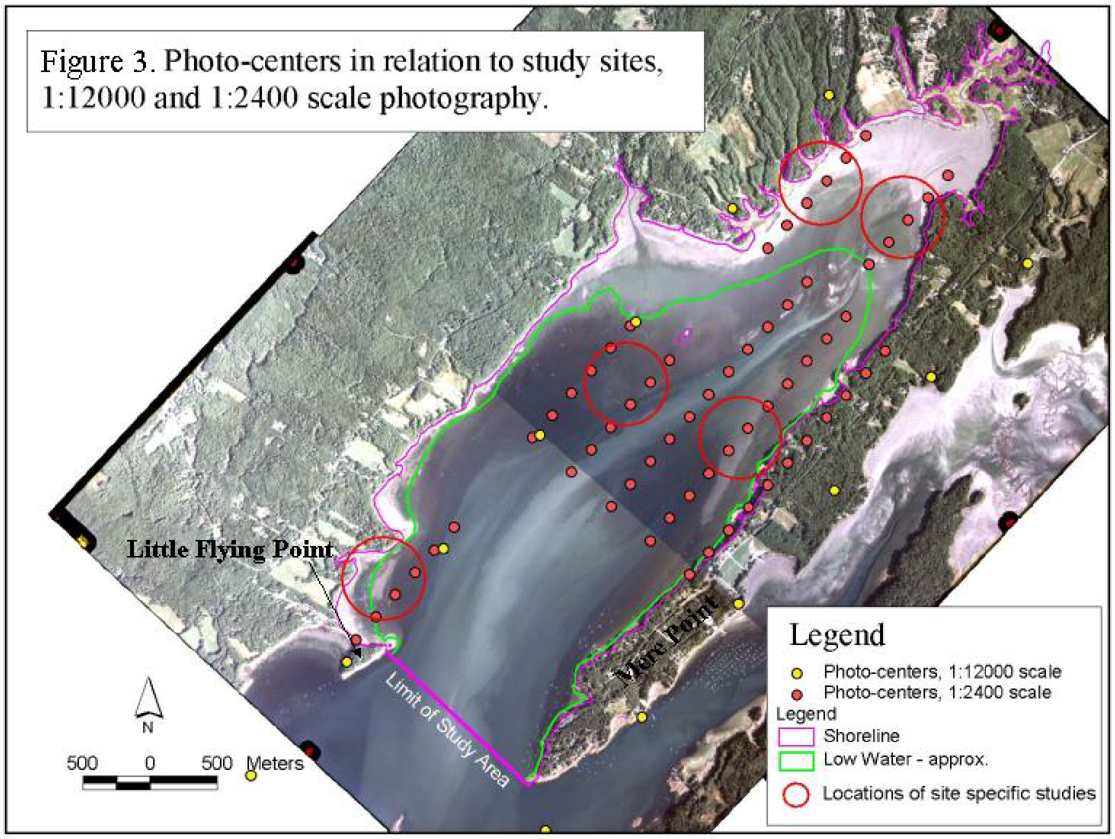
In this study, MDMR was responsible for documenting and comparing the extent of eelgrass beds in Maquoit Bay over two field seasons. This included mapping the areal extent of harvesting activities that impact eelgrass beds and documenting the patterns of re-vegetation in study areas through the use of low altitude photography. The following is a DMR agency report covering work done as part of the USGS State Partnership study. Additional studies of general patterns in distribution, population, shoot, and sediment characteristics as measured over a two-year period, and recovery projections were made. These were based on field measurements carried out by the USGS partners, Hilary Neckles and Blaine Kopp, and the UNH partner, Fred

Short. These studies and additional information from low altitude photography will be reported elsewhere.

Methods

For the purpose of this study, existing 1:24,000 scale aerial photography from August 1999 was used along with new aerial photography that was obtained at two scales in both 2000 and 2001. A scale of 1:12,000 was chosen for an overview of the Bay. Low altitude, 1:2,400 scale, photography was chosen for a more detailed documentation of patterns of vegetation at specific study sites. The main area of interest was north of a line drawn between the western most tip of Little Flying Point and the southern most tip of Mere Point. A map showing the location of the five study sites with centers of photographs at each scale is shown in Figure 3. Study sites were selected based on harvesting activities with three sites showing evidence of mussel dragging activities and one site each for recent marine worm and soft-shelled clam hand harvesting. The exact dates of harvesting activities are not known but it appeared that the mussel harvesting had taken place in previous years and that hand harvesting had taken place in the year 2000 as well as previous years (Figure 2).

Figure 3. Photo-centers in relation to study sites, Maquoit Bay.



Acquisition of Photography followed guidelines specified in the ***NOAA Coastal Change Analysis Program (C-CAP): Guidance for Regional Implementation.*** **1995. NOAA Technical Report NMFS 123. Department of Commerce.** In addition to photographs taken on August 31,1999, overflights were made on July 5, 2000 and June 26, 2001 to collect photography at both 1:12,000 and 1:2,400 scales. In advance of the 2000 flight, targets consisting of 14" and 15" automobile tires that were painted white, were placed in clearly visible locations. Each site had either three or four targets, the center of which was located using sub-meter GPS. Other landmarks that were clearly visible in 12k photos were also located with GPS to sub-meter accuracy and used along with USGS digital ortho-quarter quads to georeference photos at that scale. Prior to flights in 2001, targets were replaced with newly cleaned tires. The year 2000 photography was georeferenced using the GPS data for targets. The year 2001 photographs were georeferenced by aligning them with the 2000 photography.

Photo-mosaics of the 12k photos were made using the ESRI ArcView ™ extension, Image Analyst. Images ™ on the east and west side of the Bay were aligned in two groups and a portion of every other image combined to form a mosaic. Each mosaic was georeferenced using a combination of the USGS 24k coastline, USGS digital orthophotos, and ground control points obtained with a Trimble Pro-XL GPS unit. Though the GPS unit was used to collect control points of submeter accuracy, the overall registration of the bay-wide photo-mosaic was approximately that of the USGS 1:24,000 scale map accuracy standards. The mosaic was used to screen digitize the areal extent of eelgrass.

Low altitude photographs at the five study sites were chosen for coverage of the site and quality of the photography. Study sites that covered more than one photograph were assembled into mosaics using the same methods as used for 1:12,000 scale photos. Georeferencing was accomplished using targets mentioned above.

<u>Sea Bed Mapping</u> - Seabed mapping was done using a RoxAnn™ acoustic unit. The area was mapped over a two day period and results compared to partial data supplied by Carter Newell of Great Eastern Mussel Company. The primary objective of the seabed mapping was to document vegetative cover in subtidal locations that were not clearly visible from aerial photographs.

Ice Cover - Out of general interest, a plane flight was made in March, 2001, to document late winter conditions. A number of oblique photos were taken which were used to screen digitize an ArcView shape file showing the area under ice. This was followed by field trip to the bay where holes were drilled with an ice auger and the depth of ice and water depth under the ice were measured. The tide at the time of the field visit was near low water. Locations where holes were drilled were recorded using a Trimble ProXL GPS unit.

Scarring in 2000 was documented through an interpretation of year 2000, 1:12,000 scale photographs. Photographs were inspected for evidence of dragging, mooring damage, and unusually large areas that could not be assigned to a particular cause. All locations were screen digitized and stored as an ArcView shape file with attributes. The locations of all moorings in the bay were also screen digitized and saved as a point files. The same level of detail was not attempted for areas that had been harvested for soft-shelled clams or marine worms but general location of these activities was noted based on the patterns of digging.

Results:

In this study the 1993 eelgrass distribution as mapped by MDMR was used as a benchmark. When the bay was revisited in 1999 using 1:24000 scale photography, it was apparent that beds had expanded considerably and that there had been some damage to beds through mussel dragging activities during the interim (Figure 1). Dragging activities were focused on three locations and totaled approximately 39.8 hectares. The locations correspond to the Little Flying

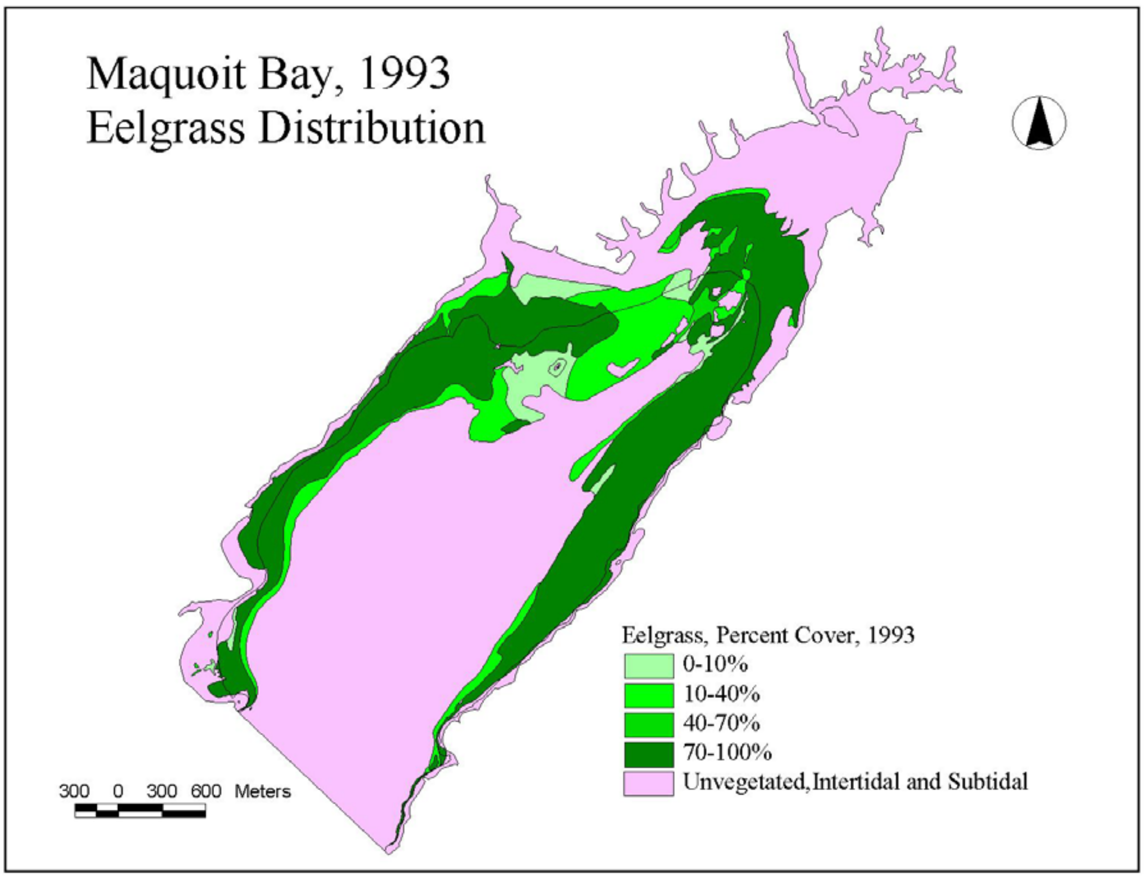
Point (LFP), 3.4 ha; Mere Point (MP), 31.8 ha; and Bunganuc (BE and BW), 18.0 ha. A chronology of events leading to visible impacts is given in Table 1.

Table 1. Characteristics of sites impacted by mussel dragging in Maquoit Bay as measured from aerial photographs (date of photograph used for area determination: BE-8/22/1993; BW,LFP, MP -7/05/2000).

Site	Area (ha)	Date of Impact
BE	8.4	1993 or Earlier
BW	9.6	Between 1993-1998
LFP	3.4	1999
MP	31.8	June 1999

The trend, based on interpretation of the 1:12000 scale photography taken in 1993, 2000 and 2001, was that eelgrass continued to expand into intertidal and shallow subtidal locations of Maquoit Bay. The distribution of eelgrass mapped from 1993 photography shows 373.2 ha of eelgrass within the portion of the bay studied (Figure 4). At that time there were intertidal and shallow subtidal locations that were clearly visible in the photography that had no eelgrass. It should also be noted that a signature for a subtidal mussel bed was clearly visible in the vicinity of Bunganuc Rock and field notes at this time confirmed presence of subtidal mussels with eelgrass percent cover of 40% or less. Other locations in the bay had at least partial coverage of eelgrass that in most cases was 70% or more. In 1993, though there was evidence of dragging at the then partially vegetated Bunganuc rock site, there was no evidence of dragging in other portions of the bay. Hand harvesting for marine worms and soft shelled clams had taken place at other intertidal locations around the bay (Figure 2).

Figure 4. Eelgrass distribution. 1993.



A more detailed analysis of change in the bay was done for 1993-2000 (Figure 5) and 2000-2001 (Figure 6). Between 1993 and 2000, eelgrass increased by 193 ha and decreased by 31 ha. (Table

2). Only small changes were seen between 2000 and 2001 (Table 2). The areas of increase generally represented expansion of beds into shallow subtidal locations. Areas of decrease primarily fell into two categories. The first was the large area denuded by dragging at the Mere point study site. The second was areas of apparent natural die-off, primarily on the western side of the bay. A further comparison between 2000 and 2001 showed an increase in the two types of areas mentioned above but additional die-offs primarily on the western shore.

Figure 5. Change in eelgrass distribution, 1993 – 2000.

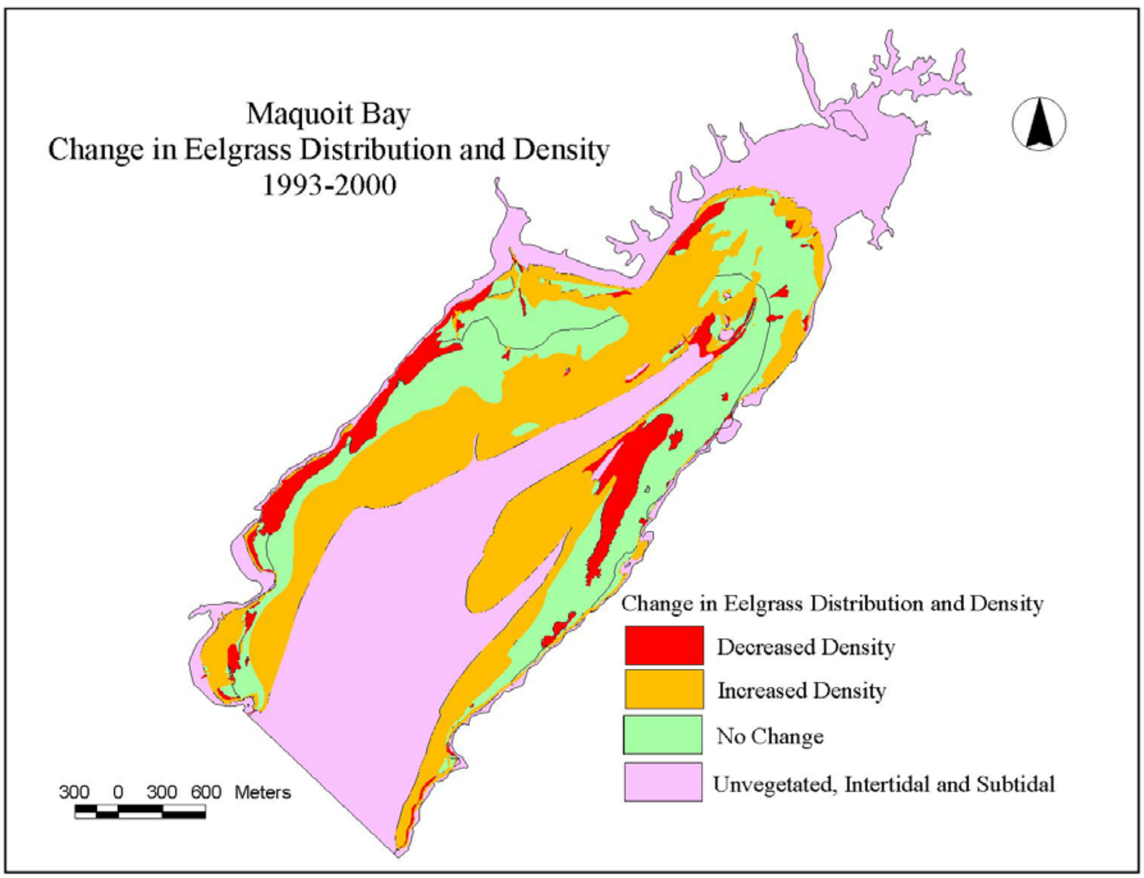


Figure 6. Change in eelgrass distribution, 2000 – 2001.

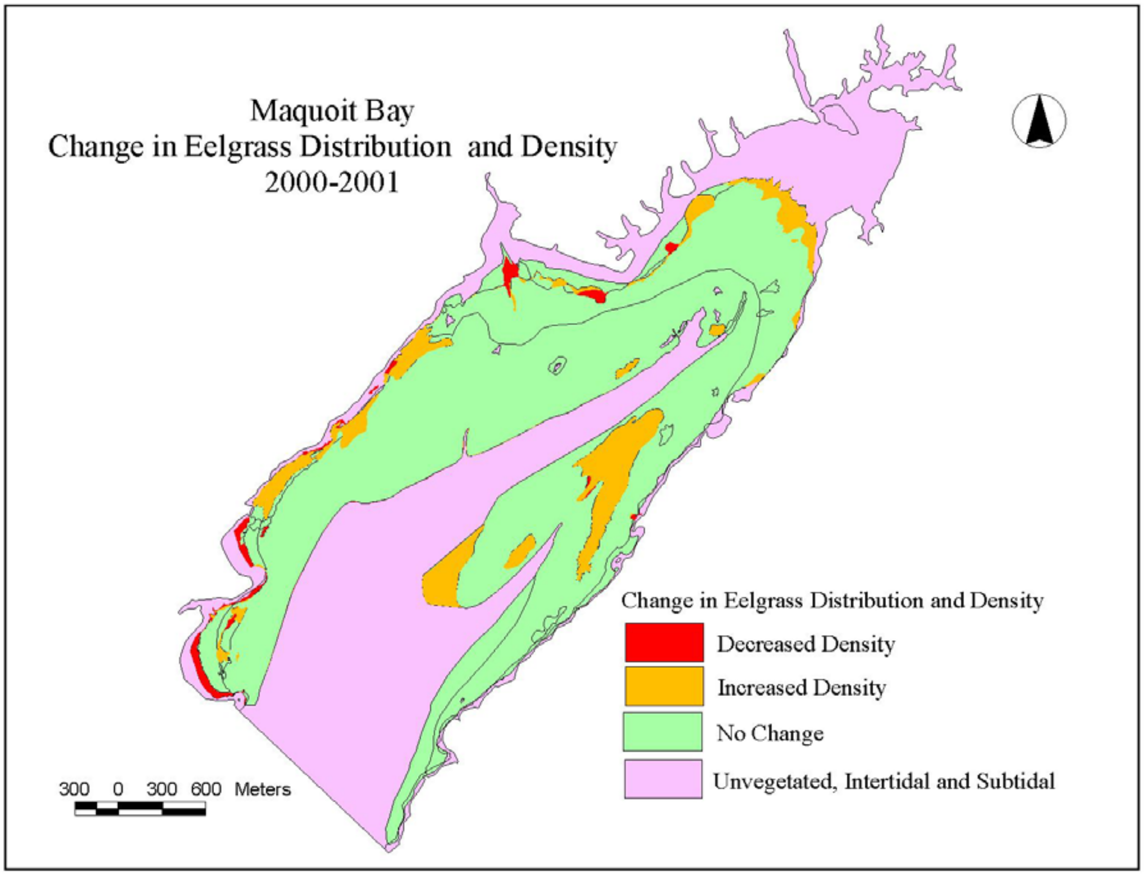
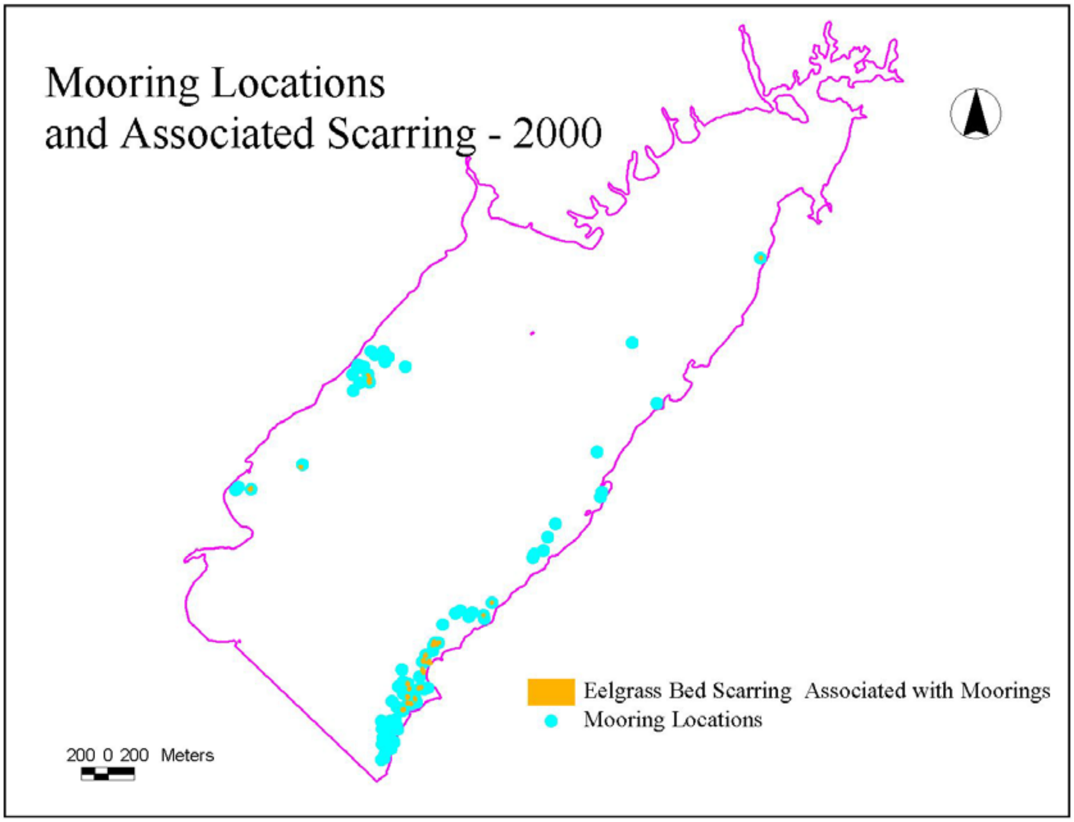


Table 2. Eelgrass cover in Maquoit Bay from 1993-2000.

	Area (ha)
Total eelgrass, 1993	373.2
Increase, 1993-2000	193.1
Decrease, 1993-2000	30.8
No change, 1993-2000	342.4
Total eelgrass, 2000	535.5
Increase, 2000-2001	37.2
Decrease, 2000-2001	2.6
No change, 2000-2001	532.9
Total eelgrass, 2001	570.1

Documentation of mooring locations and scaring due to moorings and other boat related activates is shown in Figure 7. Twenty two of 82 mooring locations detected in 1:12000 scale photography showed some degree of scarring in the immediate vicinity. Moorings were distributed throughout the bay but the majority was towards the southern end of Mere Point. This also happens to be an area that is favorable for moorings as it does not have extensive flats exposed at low water. It was difficult to assign other types of damage to boating activity but long linear features were observed that were very likely due to propellers cutting. The appearance in aerial photographs and observations in the field indicate that this was a matter of cropping rather than rhizome damage. Some of this damage was associated with mooring locations while other damage may have been associated with lobster or crab fishing

Figure 7. Mooring locations and associated scarring, Maquoit Bay, 2000.



The low altitude photography revealed limited revegetation at both the Mere Point and Little Flying Point study site. Quantification based on interpretation of photography is given in Table 3. The increase in patchy cover for those areas that had been dragged in Mere Point changed from 2% to 36% between 2000 and 2001. Likewise the increase at Little Flying Point was 12% to 24%.

Table 3. Change in eelgrass cover in sections of MP and LFP dragged areas 2000 to 2001 as measured from low altitude aerial photographs (1:2400).

	MP (m2)	LFP (m2)
Total eelgrass, 2000	500.5	4347.7
Continuous	302.9	
Patchy	197.6	
Bare	10519.5	
Total eelgrass, 2001	3733.5	6708.7
Continuous	384.0	
Patchy	3349.5	
Bare	7286.5	
Increase, 2000-2001	3325.6	3464.4
Decrease, 2000-2001	91.5	1140.1
No change, 2000-2001	408.3	3206.1
Total Area Encompassed	11020	18821
Area impacted by dragging	9151	14892

Seabed mapping using the RoxAnn ™ single beam unit revealed eelgrass west of Bungunuc Rock that was not mapped using aerial photography. The area is estimated to be 11 ha. Throughout the remainder of the bay it appears that the distribution of eelgrass was captured in the photography.

At the time the overflight was made in March 2001, ice covered 392 ha of Maquoit Bay. The extent of ice cover and locations of ice thickness measurements are shown in Figure 8. An oblique photograph is shown in Figure 9. Ice thickness averaged 0.5 meters.

Figure 8. Maquoit Bay ice cover, March 2001.

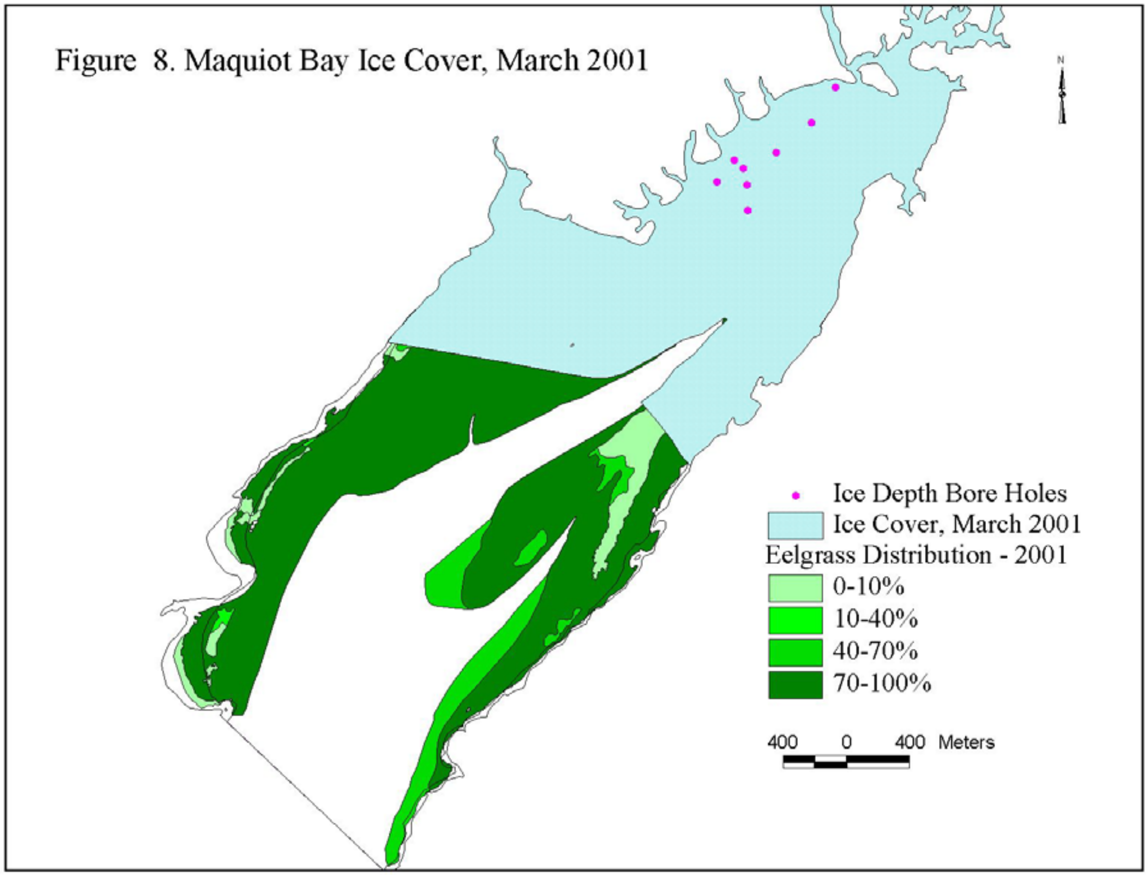


Figure 9. Oblique photograph of ice cover, March 2001

Discussion:

A clear trend was evident in the time period between 1993 and 2000 when eelgrass distribution generally increased throughout the bay. This pattern of wide distribution persisted during the time period of this study with only small changes in area cover and distribution taking place between 2000 and 2001. Expansion of eelgrass beds took place in both intertidal and subtidal locations. Maquoit Bay because of the large, poorly drained flats is the exception in terms of occurrence intertidally. In most but not all locations around Casco Bay, eelgrass is predominately found subtidally.

Though it appeared that revegetation had occurred at locations impacted by dragging, it was apparent that 1:24,000 (1999) and 1:12,000 (2000 and 2001) scale photography did not have adequate resolution to document initial colonization and low shoot densities. Gross changes were observed and documented in the small-scale change analysis while low altitude photography and field measures reported elsewhere were necessary for accurate determination of revegetation rate. Die-off due to what was assumed to be natural causes were seen primarily on the western side of the bay. Though this study did not establish cause, some locations may have been covered by windrows of eelgrass and potentially impaired. It is apparent that despite heavy ice cover, ice damage was minimal. Ice formed primarily over the intertidal portions of the eelgrass beds and was not anchored as observed during ice depth measurements. It can be assumed that some shading of the plants occurred under these conditions but ice scour did not appear to cause damage on a macro scale in 2001. Generally it appears that the conditions for expansion of eelgrass beds in Maquoit Bay were good during the 1993 – 2000 time period and continued to be so into 20001.

Seabed mapping revealed only one area of the bay that was not adequately mapped using aerial photography. In this case turbidity obscured an area of approximately 11 ha in the 2000 photography. It is not known if this area persisted in 2001.

Conclusions:

The health of eelgrass beds, at least at landscape level, was good during the time period of this study, 2000 to 2001. Considerable expansion had taken place in the time period from the 1993 survey to the present. Though the area affected by dragging could be delineated, this does not answer the question however of degree of impact from dragging and recovery time for affected portions of the beds. Finer scale studies, such as those carried out by the USGS partner and UNH, are required and will be reported elsewhere.

Acknowledgements:

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